HOW TO FLY

CAPTAIN D. GORDON E. REVLEY

Given in memory of

JOHN BEVERLY PRESTON

by Mrs. A. T. Mercier

JOHNNY PRESTON, Class of 1930, was a man in whom the spirit of competition burned deeply. As a varsity football player whose crashing end play belied his 170 pounds, he earned Coach Glenn Warner's praise as "one of the greatest ends I've ever coached."

This same venturesome spirit impelled him to turn to aviation as his life's work. Upon his graduation from Stanford, he went to Kelly Field, Texas, where he won his second lieutenant's commission in 1931. For the next five years he served as an officer in the Air Force.

In 1936, while on flying duty at Fort Lewis, Washington, he suffered a spinal injury which ultimately terminated his military career. Despite his injury, he trained Chinese cadet pilots under General Claire Chennault in 1940–41. Denied the right to fly in World War II, he served as an aircraft inspector, and later as a private flying instructor.

Paramount in his life, which ended tragically on October 11, 1949, was his devotion to three causes: his University, his country, and aviation. This, one of a collection of books established in his memory, is a tribute to that devotion.

HOW TO FLY

HOW TO FLY

(The Flyer's Manual)

A PRACTICAL COURSE OF
TRAINING IN AVIATION

BY

CAPTAIN D. GORDON E. RE VLEY

ARRANGED BY GLAD LEWIS

NINETEEN SEVENTEEN

PAUL ELDER AND COMPANY

SAN FRANCISCO

TO THOSE WHO GO UP
IN THE AIR IN PLANES

CONTENTS

PREFACE

With a desire to train an aviator into proper capability so that he may, when embarking on his career, have skillful and complete knowledge of his profession, and fly without those disastrous and unnerving consequences attendant on the average flyer's entrance into this science, brought about through inadequate and incomplete training in many of the present Aviation Schools, this manual is set forth.

Captain D. Gordon E. Re Vley, Licensed Pilot Number 191, Fédération Aéronautique Internationale, who advocates this theory of proper training, learned the frailties and faults of the Dual Control System of instruction on the fields in Europe, observing that the stu-

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ually the control of the plane becomes instinctive—he becomes part and parcel of that plane, self-reliant and efficient to counteract whatever eventuality may crop out in his flights.

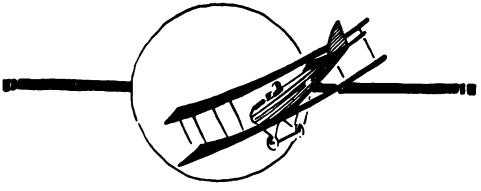
We believe a system as logical, brief and understandable as this here set down cannot fail to win the approval of schools throughout the country and the world. We hope, for the future of aviation, that a standardized and simplified and complete course, worthy of so broad a science, will be in general usage.

How to Fly *is the result of years of training, observation, instruction and experience on the part of one of America's pioneer aviators, whose work at home and abroad has won him a foremost place in the ranks of bird-men.*

His theory: "Do not rush students through their training—give them from six to nine months instruction. Haste makes waste and the results cannot fail to justify the means" should be inscribed on the door of every hangar.

Summing up, we aim for clarity in the place of technicality, for what is comprehensive as well as compact and concise in this practical course of training in aviation.

GLAD LEWIS.



THEORY

THEORY

Nine-tenths confidence plus one-tenth common-sense equals successful aviator

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WHY AN AEROPLANE FLIES:

The speed necessary to raise an aeroplane from the ground is called its *Flying Velocity.*

In order to obtain its flying velocity in the air the plane must first obtain its flying velocity on the ground.

The aviator then pulls his control toward him, which gives his elevating planes a negative angle, thereby lowering the tail and simultaneously increasing the angle of resistance offered by his main supporting surfaces.

The flying velocity plus this added resistance forces the machine into the air.

An aeroplane is as safe as its pilot

ORVILLE WRIGHT

TYPES OF MACHINES:

There are three types of fl machines, the

ORNITHOPTER, or flapping- (bird) type, unsuccessfully onstrated thus far, the

HELICOPTER, a series of pr lers minus supporting surfac the form of planes, a type als successfully demonstrated far, and the

AEROPLANE, sub-divided three classes or types, the

MONOPLANE, a single sustai surface after the manner of a with rigid wings, the

BIPLANE, two surfaces, one al the other, the

TRI- and MULTIPLANES, thre more surfaces, one above other.

There is one other sub-division which applies as well to any or all of these types of aeroplanes, the

TRACTOR TYPE, having the propelling power in the front, pulling; the

PUSHER TYPE, having the propelling power in the back, pushing.

The SEA-PLANE or HYDRO-AEROPLANE may be any one of the above types of aeroplanes with the addition of pontoons for rising from and landing on water.

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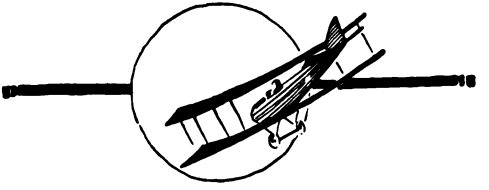

CONTROL

CONTROL

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Due to the fact that the DEPERDUSSIN CONTROL, more widely known as the "DEP," has been adopted by the United States Government, and specified for all Army and Navy Flying-Machines, the course of instruction here set forth has been arranged for this control system.

Instructors of flying who wish to apply this course to any system other than the "Dep," may do so very readily.

The student, after thoroughly familiarizing himself with the aviation terms and the construction of his plane, should commence his course of instruction in practical flying with daily two-hour sessions in the hangar.

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He should seat himself in th machine, concentrating delibe ately on his controls.

He will learn that by

Pushing the Wheel Away Fro Him, the elevating planes are lov ered, increasing their angle of r sistance and raising the tail; a action applied first in starting t clear the tail-skid from th ground, at all other times in d scending. In direct countervail, b

Pulling the Wheel Towar Him, the elevating planes a raised, increasing their angle c resistance in the opposite dire tion, thereby lowering the tail an causing the machine to rise.

Steering is done to the right an left by the action of a vertic rudder attached to a foot-ba controlled by both feet.

To Effect the Right-hand Turn it is necessary to push forward with the right foot;

To Effect the Left-hand Turn it is necessary to push forward with the left foot.

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In Flying, either in making the right-hand or left-hand turn, or due to the action of a sudden puff of wind, the machine may tilt side-ways. This tilt is counteracted through the WARPING SYSTEM or by the AILERONS.

To control the ailerons the wheel is turned away from the lower side, toward the higher side.

This action simultaneously lowers the aileron on the lower side and raises the aileron on the higher side, thereby increasing the angle of resistance of the aileron on the lower side causing

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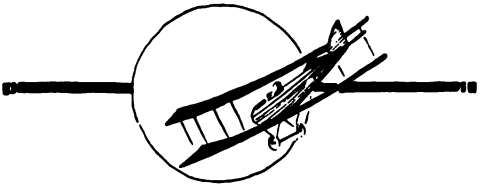
that side to come up, and increasing the angle of resistance of the aileron on the higher side in the opposite direction causing that side to come down, leveling the plane.

In Making a Turn in the air, beside the action of the foot-bar, it is necessary to counteract the bank by warping against the turn, and it is advisable to point the machine downward by pushing forward the wheel.

These three actions made at one time require the efficiency of instinct in the matter of control, obtained *only* by careful concentration in the hangar; and this is characteristic of every combination of control units.

All Movements Must be Made Slowly!



GRASS-CUTTING OR ROLLING

GRASS-CUTTING OR ROLLING

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As a precautionary measure before starting into the air it is essential that the student make it a *habit* to inspect his machine: the radiator, to ascertain the quantity of water contained therein; the tanks for the proper amount of gasoline.

It is well to remember that La Blanc lost the Gordon-Bennett Cup Race at Belmont Park, Long Island, solely because of neglect on the part of his mechanician to fill the tanks of his machine to capacity. La Blanc, himself, neglected to oversee this vital part of his equipment and ran out of fuel on the last stretch of his journey.

The student must learn to mount his machine systematically: that

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is to say, with the *least amount* of clambering.

Immediately on entering the cockpit, let him see to it that *the Motor Is Short-circuited.*

ORVILLE WRIGHT

The motor started, he is under way.

Taking for granted that the propeller is turning clockwise from the cockpit, the first movement is to shove the rudder to the right in order to counteract the

TORQUE, a moment of twisting-force due to the reaction of the propeller turning in the opposite direction. This force will always, at the start of a single-propellered machine, deviate the machine from its true course in an opposite direction to the swing of the propeller.

Simultaneously with the coun-

teraction of the torque, the wheel should be pushed forward in order to lift the tail clear of the ground.

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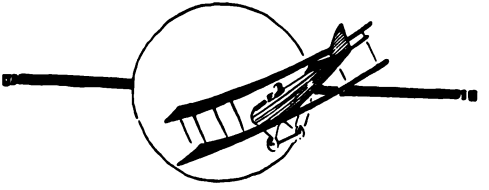
With Sufficient Practice the student can master the art of balancing his machine on a perfect level while he is rolling on the ground and running in a straight line.

Concentration on this part of the work is highly important. The most skillful of pilots are those who have spent the greater portion of their student days learning to "cut grass." Success on the ground means ultimately success in the air.

There are students who master this phase of flying very readily; others have found it difficult.

It must be "kept at," and, so, eventually conquered.



HOPPING

HOPPING

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After the student has thoroughly mastered the art of TAXI-ING (or Grass-Cutting), he may learn the sensation of leaving the ground.

The Hopping Stage means merely getting off the ground a height of several decimeters and immediately returning to earth, there being as many as twenty or thirty hops in one stretch of the aviation field.

To practice hopping, the student, after his accustomed regular inspection of his machine, which is at all times the initial action, gets under way as if he were going to "cut grass."

After the torque is counteracted and the tail leveled, and the machine seems to be skimming the

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surface of the earth, the wheel is pulled *slowly* towards him, which causes the machine to leave the ground.

Almost at once he must level out the plane by pushing the wheel *slowly* forward, never permitting the machine to rise more than two decimeters from the ground.

Flying now at an altitude of six or seven inches, by pushing the wheel forward *slowly* a fraction, thereby returning to earth, the student will have essayed his first landing.

It is essential to practice these short hops until capable of flying the entire stretch at an altitude below one meter.

This action is still a part of the student's ground-work. It is advisable to spend the greater por-

tion of the time devoted to groundwork on this particular phase. It goes without saying that the flyer who trains himself to handle an aeroplane skillfully within one meter of the ground will be equally efficient at one thousand meters. This is a most delicate and trying business. The student should elevate his plane by fractions always—not in a jerky or spasmodic manner.

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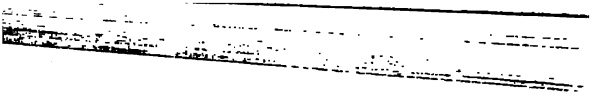

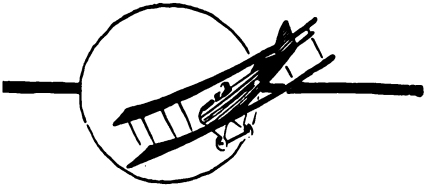

STRAIGHTAWAY

STRAIGHTAWAY

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After the student has thoroughly mastered the art of hopping he may learn the

STRAIGHTAWAY in three successive stages.

In its first stage the straightaway is the action of leaving the ground for an altitude of not over one meter and essaying a landing as soon as that altitude is reached, *i. e.*, a long hop.

In its second stage the student rises to an altitude of not over one meter and flies the entire length of the aviation field before essaying a landing.

In its final stage the student rises to an altitude of between ten and seventeen meters and flies the

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entire length of the aviation f before essaying a landing.

To make a successful straig away the student must have this time mastered his LATER CONTROL, or WARP.

To Practice the Straightaway the student, after his accustome regular inspection of his machin gets under way as if he were g ing to make a hop. As he feels t machine leave the ground, he a lows it to rise a moment long than in making a hop, and the levels out. He is now flying at a altitude of not more than on meter. By pushing the wheel *slow* forward, he descends at a ver slight angle.

Only two or three hops ar now necessary to cover the entir length of the aviation field.

In Graduating Into the Second Stage of the Straightaway, the student rises again to an altitude of not more than one meter, levels out at that height, and does his utmost to keep the machine at this exact altitude the entire length of the field.

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This is an extremely difficult feat owing to the fact that the student is now really flying—the machine is entirely at his mercy. He not only has his elevator- and rudder-controls to operate, but at this stage brings the warp, or ailerons, into play. Frequently a side wind or a sudden puff will cause the machine to tilt sideways either right or left. This tilt must be immediately counteracted by *slowly* warping against the slant.

After fully mastering the

straightaway at an altitude o
meter — being competent to
ally fly the length of the field-
student is ready to enter into

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Final Stages of Straighta
Flying, by gradually mountin
higher altitudes—by flying
length of the field successively
two-meter elevation, three-m
five-meter, seven-meter, and s
up to seventeen meters, accor
to the length of flights the are
the aviation field will permit.

It must be borne in mind
mounting an aeroplane to al
any height is a simple enough
ter; the difficulty arises in a re
to earth with a properly exec
landing. It is therefore essenti
reserve sufficient room to des
at a very slight angle, which br
us to an analysis of

LANDINGS:

Taking it for granted that the student is flying at an altitude of eight meters and wishes to land, he pushes the wheel *slowly* forward at a very slight angle. When an altitude of approximately two meters is reached, he levels out, then cuts the engine off, and keeps the machine at this slight elevation until it glides with its own velocity to the ground.

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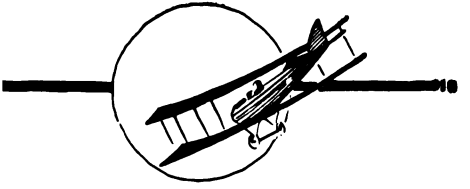

LEFT-HAND TURN AND RIGHT-HAND TURN

LEFT-HAND TURN AND RIGHT-HAND TURN

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After the student has thoroughly mastered the straightaway, he is then ready to learn the

LEFT-HAND TURN, by mounting to an altitude of eight meters, leveling out his machine, rising again another eight meters and leveling out his machine, and so on in steps until he has negotiated a height of approximately fifty meters. Leveling out at this altitude for a small distance, or as great a distance as the field will permit, the student is ready to essay his first turn.

He pushes the left foot *slowly*, warps to the right, pushing the wheel forward at the same time. The result will be a wide turn to the left with a very slight bank

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and a descent of some three to five meters.

The machine is straightened out for a second straightaway by pushing the rudder back to neutral, bringing the warp back to neutral, and leveling out. At this point it is well to ascend the altitude lost in making the turn, thus re-attaining the proximate fifty meters.

Continued flight at this height down the width of the field allows of a similar turn at the next corner, and a return down the length of the field. The fourth and last turn is made with a view to landing. The student gradually descends, and at an altitude of two meters cuts his engine off and allows the machine to glide with its own velocity to the ground.

It is advisable to repeat the left-

hand turn around the area ten or fifteen times. The student may make two or three complete circles of the field before landing, if he feels competent and so inclined.

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In making the

RIGHT-HAND TURN, the student repeats the exact processes observed in the left-hand turn *in the Opposite Direction, i.e.*, he pushes the right foot *slowly*, warps to the left, pushing the wheel forward at the same time. The result will be a wide turn to the right with a very slight bank and a descent of some three to five meters.

The machine is straightened out for further straightaway flight exactly as in the left-hand turn.

Note: An observant student will perceive that in the left-hand turn the machine will attempt to *De-*

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scend of its own accord, while in the right-hand turn it will attempt to *Ascend* of its own accord. This is due to the propeller torque.

Caution: While the pupil is actually flying it is well not to be over-confident, as over-confidence is as detrimental as lack of confidence.

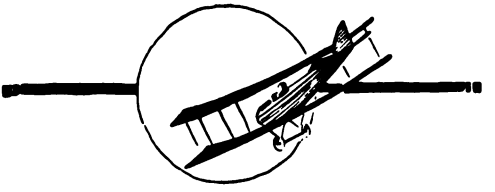

FIGURE EIGHT

FIGURE EIGHT

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After the student has thoroughly mastered the left- and right-hand turns, he is then ready to make the left- and right-hand turns one after the other, thus essaying the

FIGURE EIGHT, by leaving the ground headed for the left-hand corner of the aviation field. An altitude of fifty meters attained in successive steps (as set forth under preceding chapter), the student makes the right-hand turn at the foot of the field, and returns diagonally in a straight line, thereby crossing his former pathway in the center of the field.

At the head of the field he makes the left-hand turn, again crossing his former pathway above the center of the field, thereby complet-

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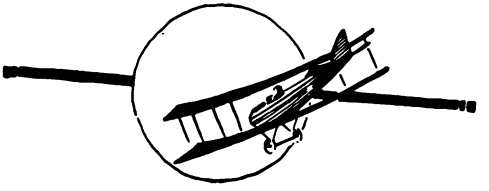
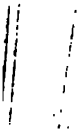
ing the figure eight and essaying a landing.

It is advisable for the student to make wide, flat circles in accomplishing the turns; not yet to attempt to bank too steeply.

Ten figure eights will suffice to master it. The student may make two or three before landing if he feels competent and so inclined.



VOLPIQUEING AND VOLPLANING



VOLPIQUEING AND VOLPLANING

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After the student has mastered the art of landing successfully with the motor on, he is ready to learn to

VOLPIQUE, by landing with the motor successively on and off.

Essaying a landing from a given height, the student points the nose of his machine gently downward at a slight angle. He cuts the engine off, glides for a few moments, turns the engine on again for a few moments still descending at the same angle, cuts the engine off again, and on again, and so on to within a distance of two meters from the ground, when, having leveled out, he cuts the engine off for the last time and allows the ma-

chine to glide with its own velocity to the ground.

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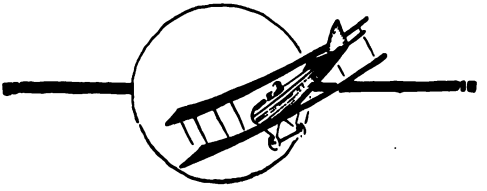
To VOLPLANE is to glide.

To essay a landing by volplaning, the student cuts his engine off at a given height, noses his machine downward gently, but at an angle great enough to assure him a flying velocity, and lands without again applying his power.

Note: It is important for the student to spend as much time as possible in the practice of landings.



PILOT'S LICENSE

PILOT'S LICENSE

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At this stage of his aviation reer, the student is ready to fly r his PILOT'S CERTIFICATE, the demand r which is as follows:

Ten Figure Eights at an altitude of fifty meters, with additional specifications and limitations.

Officials of the AERO CLUB OF MERICA lay out a rectangular urse on the aviation field. A 'lon is placed on each end of the ven course, designating the rns.

The student now takes the air, sing to an altitude of fifty meters, ıd cuts five distinct figure eights, 'ossing between the pylons and ıaking his turns outside of them.

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In landing he must cut his ... gine off five meters from t/ ground in order to glide to ea[r] and stop the machine's roll with fifty meters of the given landin point.

This process, or flight, must ... repeated.

Note: If the student has cut h figure eights below an altitude fifty meters, it is required that h make an additional flight rising fifty meters elevation.

Having accomplished his Ce tificate or License, the pilot wi now be capable of passing, if he ... desires, the

PRELIMINARY FLYING TEST as pr scribed by the United States Go ernment, as follows:

1. Three sets of figure eights around pylons 1,600 feet apart. In making turns around pylons all parts of machine will be kept within a circle whose radius is 800 feet.

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2. Stop motor at a minimum height of 300 feet, and land, causing machine to come to rest within 150 feet of a previously designated point.

3. An altitude test consisting of rising to a minimum height of 1,000 feet.

4. Glides with motor throttled, changing direction 90 degrees to right and left.

Note: 1 and 2 may be executed in one flight; 3 and 4 in one flight. The same rules apply in starting from and landing on water. Spe-

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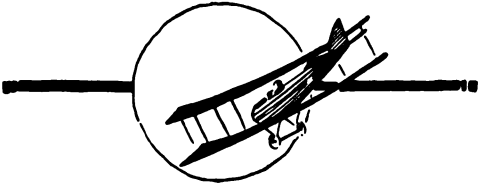
cial attention will be paid to the character of landings made.

Report of these tests will be submitted to the officer in charge of the aviation section, with the information as to whether or not the school will complete the training of the aviator through the reserve military aviator stage.

If the preliminary flying test is passed satisfactorily, and a candidate qualifies in other respects, he will be eligible for further instruction to qualify as a reserve military aviator.

Therefore the pilot undertakes a more thorough understanding of aviation which is here set forth.



DAILY PRACTICE

DAILY PRACTICE

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The student is now a recognized aviator—a pilot, and is starting on approximately the sixth month of his instruction.

A systematic method of putting into practice the course he has undergone, with the addition of "stunt" flying necessary to complete the knowledge of an expert aviator, makes up the final month's program.

On the First Day, then, the pilot should take his machine up to an altitude of between four hundred and a thousand meters, and practice volplaning and volpiqueing from these altitudes. During these long descensions, he should undertake and practice the

SPIRAL GLIDE or SPIRALING, a

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method of descending in wide ci cles, corkscrew fashion.

On the Second Day the pil should mount to the same altitu and execute similar spiral glide narrowing the circles to a small and smaller degree.

On the Third Day he may mal the circles still smaller, and so o until at the end of a week of th exacting practice *in Dead Cal Weather,* he is capable of skil fully executing a very sharp spir dive.

It is essential to know the spir dive since the aviator may h placed in the tight position of fin ing himself directly over a lan ing-spot in some city with h motor "gone dead." The only po sible safe landing then is a spir dive.

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The Second, Third and Fourth Weeks should be made up of short cross-country flights, steep-banking and steep-diving at safe altitudes, climbing, and calculated landings.

To Practice Calculated Landings the pilot should climb to an altitude of at least a thousand meters, cut his engine off, and land as closely as possible to a predesignated spot.

When the pilot is capable of landing from an altitude of a thousand meters with his engine off to within a hundred meters of a predesignated landing-spot, he should then undertake and practice

OBSTACLE LANDING, after the following manner:

Assuming that a ten-foot fence is placed at one end of a field five

An oplane is as safe as its pilot

RVILLE
/RIGHT

hundred meters in length, the aviator, flying at an altitude of not under a thousand meters, finds his engine "gone dead." He starts a spiral glide in wide circles. His only available landing-spot, he discovers, is this field, the only entrance to which is by passing over this ten-foot fence.

Called upon to descend, he passes over the fence as closely as he can skim it with safety, in order to land within the five hundred meters of the field.

It is well to practice this emergency landing on the aviation field as the pilot may be called upon to execute it at some future date.

In Climbing, the usual practice is made up of wide circles.

The pilot should leave the ground, climbing gradually. It is

very easy to stall, and stalling is the most dangerous predicament a mounting aviator can get into.

At the completion of his month of daily practice in the air, the pilot is ready to fly for his EXPERT AVIATOR'S CERTIFICATE.

Nine-tenth confidence plus one-tenth common-sense equals successful aviator

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EXPERT AVIATOR'S CERTIFICATE AND MILITARY BREVET

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THE DEMANDS OF THE EXPERT AVIATOR'S CERTIFICATE are as follows:

> *A fifty-mile (appx. 32 kilometers) cross-country flight, twenty-five miles (appx. 16 kilometers) and return. Ascension to an altitude of at least 2,500 feet (appx. 770 meters), and a volplane to within 100 meters of a predesignated point.*

The pilot is from now on recognized by the AERO CLUB OF AMERICA (Fédération Aéronautique In-

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ternationale) as an EXPERT AVIATOR, and he is capable of passing, if he so desires, the

RESERVE MILITARY AVIATOR TEST as prescribed by the United States Government, as follows:

1. Climb out of a field 2,000 feet square and attain 500 feet altitude, keeping all parts of machine inside of square during climb.

2. Glides at normal angle, with motor throttled. Spirals to right and left. Change of direction in gliding.

3. At 1,000 feet cut off motor and land within 200 feet of a previously designated point.

4. Land over an assumed obstacle 10 feet high and come to rest within 1,500 feet from same.

5. Cross-country triangular flight of 30 miles, passing over two previously designated points. Minimum altitude 2,500 feet.

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6. Straightaway cross-country flight of 30 miles. Landing to be made at designated destination. Both outward and return flight at minimum altitude of 2,500 feet.

7. Fly for forty-five minutes at an altitude of 4,000 feet.

If, in addition to the preliminary flying test the candidate also passes the reserve military aviator's test satisfactorily, he will be given a commission in the aviation section, Signal Officers' Reserve Corps, provided all other (physical, educational) qualifications are fulfilled.

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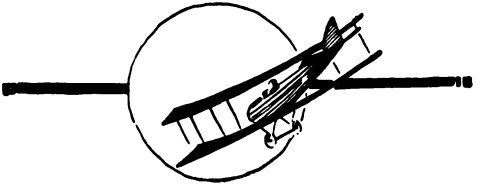
The expert aviator's continued practice in the air, then, should be in accordance with the stipulations and demands of the Reserve Military Aviator Test.



SUGGESTIONS TO INSTRUCTORS

SUGGESTIONS TO INSTRUCTORS

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Gather the students together when the weather is not propitious for flying and, in a body, carry on weekly discussions covering every phase of aviation.

Such problems as come up in the every-day flying should be freely gone into, and the students' opinions on what they would do when placed in awkward predicaments, solicited.

As an example of such problems, ask the students what they would do were they caught in a ninety-degree head-on dive from an altitude (at which time, of course, the elevators would not straighten-out the machine).

The correct answer would be:

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To deviate the machine from its course by steering out of it with the rudder, either right or left, and then elevating.

Ask the students what they would do if the machine were suddenly turned upside-down.

They should reply to this: Regain normal flying position by pulling the wheel toward the pilot and executing the bottom half of the letter S, coming out of the dive as set forth in the previous problem;

Or, by shoving the rudder right or left and warping with the turn, rolling wing over wing.

The students will suggest their own problems from their daily flying experiences, and will learn by the mistakes of others how to

avoid and nullify danger in the sky.

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The instructor should take up for discussion famous catastrophes of famous flyers, setting forth the solution that would have saved each in turn. These actual cases will serve as a splendid guide to students, will broaden and expand their knowledge of aerial science, will teach them to be self-reliant, to express their own opinions and deductions, to think rapidly and to the point.

It is advisable to arrange a card-system for "checking-up" purposes, inscribed with the name of each student, the number of his flights, his progress, and requirements of practice. Some students need more attention, encouragement, and actual flying-practice than others, and this systematic

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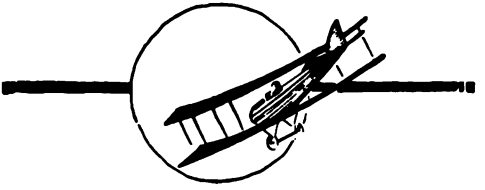
method of chronicling each candidate enables the instructor to follow along individual lines the tuition in his school.

It is Further Respectfully Suggested that Aviation Schools throughout the country lengthen their course to include instruction for the Expert Aviator's Certificate, which will enable the candidate to acquire, with the least possible delay, his Military Brevet.



METRIC SYSTEM

METRIC SYSTEM OF LENGTHS AND THEIR RELATIVE VALUES

MILLIMETER

is 1/1000 of a meter or 0.0394 inch.

CENTIMETER

is 1/100 of a meter or 0.3937 inch.

DECIMETER

is 1/10 of a meter or 3.937 inches.

METER

is 1 meter or 39.37 inches.

DEKAMETER

is 10 meters or 393.7 inches.

HECTOMETER

is 100 meters or 328 feet, 1 inch.

KILOMETER

is 1,000 meters or 0.62137 mile (3,280 feet, 10 inches).

MYRIAMETER

is 10,000 meters or 6.2137 miles.

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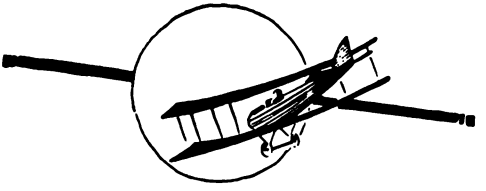

GLOSSARY

GLOSSARY

AS COMPILED BY

ALFRED W. LAWSON

(EDITOR OF "AIRCRAFT")

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aeroboat (ā-ē'rō-bōat), a combination boat and aeroplane.

aerocar (ā-ē'rō-car), an enclosed passenger-carrying flying machine.

aerodonetics (ā-e-rō-do-net'iks), the science of gliding or soaring flight.

aerodrome (ā-ē'rō-drōm), (1) a flying race-course; (2) a structure for housing aerial vehicles; (3) a name proposed for flying machines and used by Prof. S. P. Langley for his tandem-planed machine (1896), now entirely superseded in this sense by the word aeroplane.

aerodynamics (ā-ē-rō-dī-nam'ics), the science of the air, of gaseous fluids and their forces.

aerofoil (ā-ē'rō-foil), a thin plane or curved structure suited to motion in

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the air; the sustaining member of the aeroplane; an experimental plane surface of varying shape, used on the whirling table for ascertaining the most efficient outlines and forms for use in aeroplanes and propellers.

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aeronaut (ā-ē'rō-nawt), a navigator of the air, particularly a balloonist or pilot of a lighter-than-air flying machine.

aeronautics (ā-ē-rō-nawt'iks), the entire science of aerial navigation. See *aviation.*

aeroplane (ā-ē'rō-plān), a self-propelled, heavier-than-air flying vehicle having fixed sustaining planes or surfaces, supported dynamically by its movement through the air, also known by the names aerodyne, aerodrome, flying machine, aeromobile, etc.

aerostatics (ā-ē-rō-stat'iks), the science of buoyancy in the air by means of displacement.

aerostation (ā-ē'rō-stā-shun), that part

of aerial navigation dealing with gas-borne or lighter-than-air machines.

aileron (ā'le-ron), an auxiliary plane, flap or wing tip, placed near the extremity of the main wing of the aeroplane, on either side, and operated so as to prevent overturning sideways, and to assist in steering.

aircraft (ār'kraft), (1) any human device that flies or floats in the air or pertaining to the construction thereof; (2) the aeronautical industry.

airship (ār'ship), a self-propelled lighter-than-air vessel for navigating the air; a dirigible, distinguished from an aeroplane or other heavier-than-air flying machine.

alighting-gear (ă-līt'ing-gēr), the portion of an aeroplane used in landing, including wheels, skids, underbody, shock-absorbers, etc.

anemometer (a-nē-mom'e-tēr), an instrument for measuring the forces of the wind, velocity, pressure, etc.

angle (ang'gl), (1) "of entry," the an-

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gle which the tangent to the leading convex edge of the surface of a plane makes with the chord; as, "an angle of entry of 45 degrees;" (2) "of incidence," the upward inclination of the planes of an aeroplane entering the air, when flying horizontally, usually from 5 to 12 degrees; also angle of the chord of the rib with the horizontal.

ascension (as-sen'shun), the act of ascending in a lighter-than-air device.

ascent (as-sent'), to ascend in a lighter-than-air vehicle. See *flight.*

aspect-ratio (as'pekt-rā'shi-ō), proportion of fore and aft dimension to transverse span; as, "1:6," the proportion of five feet of depth to thirty feet of width of the plan of the plane of an aeroplane.

aviation (ā-vi-ā'shun) or (av-i-ā'shun), the art, act, practice or science of mechanical flight in heavier-than-air machines; distinguished from aeronautics, which refers more to the science of ascension in lighter-than-air machines and balloons.

Aeronautics includes, in a certain sense, aviation, but is becoming more definitely differentiated and restricted to the latter meaning, aviation being the dominant word in reference to aeroplanes and aeroplaning.

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aviator (ā'vi-ā-tor), or (av'i-ā-tēr), a navigator of the air, in heavier-than-air machines, an aeroplane driver, also called airman, aeroman, birdman, flyer, pilot.

Avion (av'i-on), name of the first heavier-than-air flying machine, invented by Ader and flown in France 1897, with two steam engines.

balancing-plane (bal'ans-ing-plān), a surface, flap, web or other member for maintaining equilibrium.

balloonet (ba-lōōn-net'), a cell or subsidiary small balloon making up with others the interior of a larger balloon or dirigible, some of which usually contain air, so that in rising temperatures, the opening of the air balloonets gives room for the expansion of gas in the gas balloonets.

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banking (bank'ing), making a turn with the inner side of the aeroplane downward.

barograph (bär'ō-graf), a form of barometer which automatically registers the altitude reached by an aeroplane and makes a record on a continuous strip of paper of the variations in altitude.

beam (bēm), the principal transverse member of the plane or wing to which the ribs are attached; *front beam—rear beam.*

biplane (bī'plān), an aeroplane having two main planes usually of equal size, one above the other. *Staggered biplane* (stag'ẽrd), one with planes offset, fore-and-aft manner. *Tandem biplane* (tan'dem), one with two main planes on the same level, one some distance behind the other.

camber (kam'bẽr), the concavity or arch of an aeroplane wing as seen from the side of the machine when looking at the end of the wing; the fore and after curvature; the Phillip's curve, imitative of the con-

cavity of the underside of a bird's wing, the application of which to aeroplanes proved one of the greatest elements of progress ever introduced; in biplanes, usually of a depth of one-twentieth of the span.

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cavitation (kā-vi-tā'shun), the formation of a partial vacuum in the zone of a rapidly revolving propeller due to its velocity.

center (sen'tēr), *center of flying gravity;* center of gravity of air-craft when in flight. *Center of pressure or resistance,* the point at which the resistance balances; or at which, if concentrated, it would have the same effect as when distributed.

center of thrust or pull, the point at which the driving force may be assumed to act. In an aeroplane flying in a normal state the centers of gravity, resistance and thrust form an equilibrated couple.

chassis (shas'si), the main framework of an aeroplane to which the essential members are attached; the understructure.

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control (kon-trōl), *front control* (frunt), the elevator or auxiliary plane forward and its attachments for vertical direction of an aeroplane. *Lateral control* (lat'ĕr-al), apparatus for regulating the list of the aeroplane.

control-lever (kon-trōl'lēv-er), a lever for steering an aeroplane either up or down or from side to side, or for maintaining lateral balance.

cross-country flight (krôs-kun'tri flīt), a flight over open or unprepared fields.

cruising radius (krūz'ing rā'di-us), the distance from a given point which marks the radius of a circle over which an aerial vehicle may conduct cruising operations.

curtain (kĕr'tin), a fixed vertical surface located on the ends between the main-planes. See *vertical plane.*

deflector (de-flek'tĕr), a plane or other surface for changing course of an aerial vehicle.

demountable (dē-mount'a-bl), capable

of being readily taken apart to the extent necessary for transportation; as, a "demountable military aeroplane."

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dihedral (dī-hē'dral); *dihedral angle*, the inclination of the wings of an aeroplane to each other, usually in the form of a flat V, the outer ends high, when viewed from the front, a form giving stability but dangerous in side winds if the machine banks. Mostly used on monoplanes.

dirigible (dir'ij-i-bl), steerable; also a self-propelled balloon, an airship, as Zeppelin's dirigible, usually cigar-shaped and of great size.

distance-piece (dis'tans-pēs), a piece holding other parts at required intervals; as, "distance-pieces between ribs."

double-decker (dub-l-dek'ẽr), an aeroplane with two sustaining surfaces superposed; a biplane, as a "Farman double-decker."

double-surfaced (dub-l-sẽr'fast), a

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plane covered on both the upper and under side of the ribs.

edge (ej), *entering edge* (en'tĕr-ing), the front edge of the planes of an aeroplane; *trailing* (trāl) *edge*, the rear or leaving edge of the plane.

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elevator (el'e-vā-tĕr), a horizontal plane, either fore or aft of any flying device, used to steer it in an upward or downward direction.

equalizer (ē'kwal-ĭz-ĕr), an auxiliary plane or device for lateral stability.

fin (fin), a small plane, flipper or blade for purposes of ensuring greater equilibrium; mostly on dirigibles.

flight (flīt), rise and passage of an aeroplane through the air, distinguished from ascent, the rising of a balloon.

flying-machine (flī'ing-ma-shēn'), an apparatus or vehicle for navigating the air, including all kinds of heavier-than-air machines; any flying vehicle or device.

fuselage (fū-si-lāj'), (1) the framework of an aeroplane or dirigible;

(2) that portion of a monoplane extending from the main body to the tail.

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glider (glī'dēr), an apparatus without power for aerial gliding, constructed of planes, designed to carry an operator, his balance being maintained by shifting his position; as Lilienthal's glider. *Biplane-glider,* the type perfected by Chanute, which, when improved and fitted with an engine by the Wrights, became the biplane.

gliding-angle (glīd'ing-ang'gl), the angle at which an aeroplane travels when the power is cut off.

gyroscope (jī'ro-skōp), a device in which the axis of a heavy rotating body is also free to rotate in any direction and may be acted on by couples of forces. Numerous efforts have been made to utilize the resistance of a gyroscope to deflection from its plane as a means of maintaining lateral balance in aeroplanes.

hangar or ***hanger*** (hang'gär), (hang'gēr), a structure for housing aerial

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vehicles; aeroplane shed. (The term is derived, through the French, from an old Persian word for a post-station.)

headless (hed'les), without a head; a biplane having no front elevator, such as the Wright headless.

head resistance (hed re-zist'ens), that portion of the resistance encountered by an aerial vehicle in flight which cannot be utilized to assist in its support; dead resistance.

helicopter (hel'i-kop-tēr), or (hē'li-kop-tēr), an aerial vehicle sustained and propelled by the action of the screws, propeller or rotating planes and without supporting planes; a form advocated by many scientists but not yet perfected mechanically.

hydroaeroplane (hī-drō-ā-ē'rō-plān), an aeroplane capable of alighting on and rising from the water (such as Curtis' hydroaeroplane), distinguished from an aerohydroplane, a hydroplane with wings, not capable of rising entirely free of the water.

ignition (ig-nish'un), the means of exploding the mixture in an internal combustion motor, usually an electric spark from a magneto.

knock-down (nok'doun), a flying machine as dismantled for shipment, or its collected parts prior to erection.

lacing (lās'ing), cord or string used in fastening the cloth covering of planes together, and to the ribs and beams.

landing-chassis (land-ing-shas'si), the landing framework or under body of an aerial vehicle.

launching (launch'ing); *launching derrick* (der'ik), a catapult for starting a flying machine; *launching rail* (rāl), a track or bar for launching into the air.

lifting propeller (lift'ing pro-pel'ẽr), a propeller for raising flying machines without forward movement.

list (list), careen or incline sideways of an aerial vehicle; banking.

lubrication (lū-bri-ka'shun), *splash lu-*

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brication, oiling of internal parts of motor by working parts splashing in a sump of oil.

mast (mast), upright part, usually extending upward from the center of a monoplane for support of guy and truss wires and controls. A vertical upright in either the main or supplementary planes.

monoplane (mon'ō-plān), an aeroplane with a single main sustaining surface, or with a single wing on either side of the body. *Tandem monoplane* (tan'dem), a monoplane with two main planes, one in front of the other, not superposed. A *biplane* (bī'plān), has two planes, a *triplane* (trī'plān), three planes, and a *multiplane* (mul'ti-plān), a greater number.

ornithopter (ôr-ni-thop'tĕr), a heavier-than-air aerial vehicle with flapping wings, imitative of bird flight.

outrigger (out'rig-ĕr), framework extending to the front or the rear to support the elevator or tail.

Phillips' curve (fil'ips kẽrv), the curve similar to the underside of a bird's wing applied by Phillips to the aeroplane. See *camber.*

phugoid (fū'goid), *phugoid curve,* a curve showing the flight-path of an aerofoil.

pitch (pitch), the distance through which a given point of a propeller advances during one revolution, parallel to the axis, in a solid nut.

plane (plān), a supporting surface of an aeroplane.

pocket (pok'et), a loop formed either in the end of the cloth surface or by sewing on an additional strip; provided for the ribs and beams of a single-surfaced plane to lessen skin friction.

power-plant (pow'ẽr-plant), the entire apparatus for generating power on an aeroplane, including motor, propeller, radiator, gasoline tank, etc.

propeller (prō-pel'ẽr), a device with two or more blades set at a pitch

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which translates rotary force into straight line motion; a screw; *tractor propeller* (trak'tor), a propeller on the front of an aeroplane, drawing the machine forward, as on the Bleriot monoplane.

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pterygoid (ter'i-goid), having the shape of a wing, as "pterygoid aspect."

pylon (pē-long), a mark in the course of an aerodrome.

rib (rib), a longitudinal horizontal member of an aeroplane wing, to which the covering is attached, and whose shape determines the curve of the wing. *Laminated rib*, a rib built up of laminations of wood, glued together to enable it to hold its shape.

rudder (rud'ĕr), an auxiliary plane or surface either at front or rear of an aerial vehicle for steering; also called *vertical rudder* (vĕr'ti-kl). The *horizontal rudder* (hor-i-zon'-tal) is for steering up or down, and the stabilizing rudder or aileron for maintaining equilibrium.

running-gear (run'ing-gēr), that part of a flying machine which enables it to travel on the earth.

shock-absorber (shok'ab-sôrb-ēr), an apparatus for deadening the impact of an aeroplane upon alighting.

single-surfaced (sing'-gl-sēr'fast), a plane covered on only one side.

skid (skid), a sled-like runner, part of the running gear of an aeroplane.

skin-friction (skin'frik-shun), the friction between the surface of the planes and other parts of the flying machine, and the passing air; distinguished from the head resistance due to displacement of the air; much less for smooth surfaces than for rough ones; skin resistance.

slip (slip), the loss of efficiency of a propeller, the difference between its theoretical advance and the real advance in practice. See *pitch*.

soaring (sôr'ing), flight without power, effected by taking advantage of rising, or unequal currents of air.

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spread (spred), distance from tip to tip of wings of an aeroplane, as "the spread of a Curtis is 28 feet."

stability (sta-bil'i-ti), steadiness in flight; *automatic stability* (aw-tō-mat'ik), maintenance of equilibrium in automatic manner. *Longitudinal stability* (lon-gi-tū'di-nal), steadiness in a fore-and-aft direction; *horizontal* or *lateral stability* (lat'ēr-al), steadiness from side to side.

stabilizer (stā'bl-īz-ēr), a plane or other device for securing steadiness.

staggered (stag'ērd), arranged in steps or offset; zig-zag, said of planes of aeroplane.

stanchion (stan'shun), an upright between the planes of a biplane, a post, a strut.

steering (stēr'ing), guidance of an air-craft in flight. *Vertical steering*, up and down as distinguished from *lateral* or *right* and *left steering*.

stream-line-form (strēm'līn-fôrm), that form of a body which enables it to

pass through liquid or gas with the best possible resistance; ichthyoid, or fish-like form.

strut (strut), a brace or support under compression stress; an upright between planes.

tail (tāl), rear portion of an aerial vehicle used for steering and balancing.

tetrahedral cell (tet-ra-hē'dral sel), a tetrahedron whose sides are four equilateral triangles, open front and rear, the sides being surfaces. A large number of such cells when built up acting as a sustaining surface, as in the tetrahedral aeroplane of Prof. Alexander Graham Bell.

thrust (thrust), the push or traction exerted by the propeller; as, "the propeller developed 350 pounds thrust," i. e., showed on a scale 350 pounds pull to hold the aeroplane motionless.

torque (tôrk), moment of twisting force; the force tending to overturn an aeroplane sideways, due to the

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reaction of the propeller in turning in the opposite direction, overcome by having two propellers operating in opposite directions or making the wing on one side slightly larger than the other.

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turnbuckle (tĕrn'buk-l), a connection for tightening wires, rods, etc., consisting of right and left hand threaded eyelets or swivels in a sleeve, the turning of which varies its length.

velocity (ve-los'i-ti); *natural velocity* (nat'ū-ral), the speed at which an aeroplane will continue to glide indefinitely without power.

volplane (vōl'plān), to glide or coast without power in an aeroplane.

wake (wāk), track or stream of disturbed air following the course of an aeroplane.

war plane (wawr' plane), an aeroplane designed for use in warfare.

wash (wash), the disturbed air immediately behind an aerial vehicle; dead air.

web (web), wooden or other material used as distance pieces between the ribs of a sustaining plane.

whirling-table (hwhĕrl'ing-tā-bl), an apparatus comprising a vertical axis and a horizontal arm for revolving planes or aerofoils and determining their effects and efficiency. The use of the whirling-table led to the experimental determination of numerous aerial laws and directly to the perfection of the aeroplane.

wind-pressure (wind'presh-ūr); *coefficient of wind pressure* (kō-ef-fish'ent), the numerical constant of the pressure of the wind against a stationary object, or of the resistance of the air to a moving object.

wing (wing), one of the pair of sustaining planes of a monoplane; a sustaining surface.

wing-spread (wing'spred), area of surface of wings; distance from tip to tip.

wing-surface (wing'sĕr-fas), wing area, surface measurement of wing.

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wing-tip (wing'tip), the outer extremity of the wings of a monoplane; an aileron or other movable surface at end of wing.

wing-warping (wing'wawrp-ing), deflection of a portion of an aeroplane wing; as the Wrights' warping wings; the bending of the rear outer corners of the wing on one end in an opposite direction from those of the other end, attaining lateral equilibrium.

THIS IS THE BOOK "HOW TO FLY," WRITTEN BY CAPTAIN D. GORDON E. RE VLEY FOR THE MANY WHO DESIRE THIS KNOWLEDGE, ARRANGED BY GLAD LEWIS, AND PUBLISHED BY PAUL ELDER AND COMPANY UNDER THE SUPERVISION OF RICARDO J. OROZCO, THEIR PRINTER, DURING THE MONTH OF JULY, NINETEEN SEVENTEEN